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PROGRESS REPORT ON FIRES FOLLOWING THE 1995 GREAT HANSHIN-AWAJI EARTHQUAKE

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INTRODUCTION

At 5:46 a.m., on January 17, 1995, an earthquake, with an epicenter only 14 km under the ground and hypocentral region just beneath Kobe and other cities between Kobe and Osaka, registered 7.2 on the Richter scale. As Kobe city is Japan's sixth largest city with a population of 1.4 million, the damage caused by this massive earthquake was the worst in postwar Japan. The Great Hanshin Earthquake destroyed more than 200,000 buildings killing more than 5,500 people, and injuring and burying over 40,000 others. More than 200 fires broke out after the earthquake and burnt down more than 7,000 houses or areas covering over 65 hectares, killing more than 350 people who had been buried under the damaged structures.

Investigations were conducted by fire departments and several researchers at universities and research institutes. The following summarizes the findings of the investigations following this earthquake.

IGNITIONS AND CAUSES OF FIRES

During the first 3 days following the earthquake, more than 200 fires occurred in the Hyogo and Osaka prefectures . Of those, 138 fires took place in Kobe city. Table 1 lists the number of post-earthquake fires by date in 7 cities where the damage of structures was very severe. In the 13 minutes after the earthquake, 60 fires broke out in Kobe city. Fire Research Institute collected data on fire incidents which occurred in 10 days after the earthquake from fire agencies in these areas. [1,2]

Kobe Fire Department investigated 175 fires which occurred in 10 days after the earthquake. 81 ignition sources and scenarios have been identified. 44 fires were caused by electric appliances and electrical system malfunctions, 5 fires by gas heaters and stoves, 5 fires by kerosene heaters and 6 fires were associated with gas leaks. Causes of 94 cases have not been identified because the fire were too severe to find any evidence. [1] Because fire suppression and emergency response were the primary priorities following the earthquake, their investigations were not conducted in a timely manner.

Researchers at the Kobe University headed by Professor Murosaki Yoshiteru investigated the causes of the fires by hearing about 400 people who observed the fire. They conducted this investigation from 3 days after the earthquake until February 5. Their investigation covers 181 fires which occurred in 3 days after the earthquake in Kobe, Amagasaki, Nishinomiya, Ashiya, Takarazuka, Itami and Kawanishi city. They pointed out that more than half of the causes were associated with gas and electricity and this tendency is similar to the fire causes of the Northridge earthquake. [3, 4]

Fire Investigation Section at National Research Institute of Police Science conducted a study on causes of electrical fires following the Great Hanshin Earthquake. Data on the ignition time of fires and the recovery time of electricity were collected and it was concluded that some fires occurred as the result of electricity recovery. [5]

Table 1. Number of Post-earthquake Fires by Date in Kobe and adjacent areas in Hyogo and Osaka Prefectures. [1),2)]

Name of Ward and City	Jan. 17 -6:00	Jan. 17 -9:00	Jan. 17 -12:00	Jan. 17 -24:00	Jan. 17 Total	Jan. 18 Total	Jan. 19 Total	Total
Higashi-Nada	10	4	0	3	17	2	4	23
Nada Ward	13	2	1	1	17	2	0	19
Chuo Ward	8	7	2	3	20	3	3	26
Hyogo Ward	11	3	2	1	17	4	3	24
Nagata Ward	12	2	2	1	17	1	4	22
Suma Ward	4	7	2	0	13	2	1	16
Tarumi Ward	0	4	1	1	6	0	0	6
Kita Ward	0	0	0	1	1	0	0	1
Nishi Ward	1	0	0	0	1	0	0	1
Kobe City	59	29	10	11	109	14	15	138
Ashiya	4	5	0	0	9	2	2	13
Nishinomiya	11	13	2	4	30	2	3	35
Takarazuka	2	0	1	1	4	0	0	4
Itami	2	5	0	0	7	0	0	7
Kawanishi	1	2	0	0	3	1	0	4
Amagasaki	3	3	1	1	8	0	1	9
Akashi	0	1	4	1	6	1	0	7
Awaji	1	1	0	0	2	1	0	3
Hyogo Pref.	83	59	18	18	178	21	21	220
Osaka City	7	6	1	2	16	2	2	20
Toyonaka	2	3	0	1	6	1	2	9
Suita	1	1	0	0	2	1	0	3
Takatsuki	1	0	0	0	1	0	0	1
Sakai-Takaishi	1	0	0	0	1	1	1	3
Osaka Pref.	12	10	1	3	26	5	5	36
Total	95	69	19	21	204	26	26	256

AREA OF CONFLAGRATIONS AND FIRE STOP FACTORS

Building Research Institute investigated the buildings surrounding the 150 fires. Maps indicating types of buildings surrounding the fires were made and areas were measured. Table 2 lists the number of large fires (burned area, 3,300m^2 -) , medium-sized fires (1,000-3,300m^2) , small fires (-1,000m^2) , confined fires and fire loss. 7 fires spread over 33,000 m^2. [6]

Fire Research Institute investigated fire stop factors for the 22 large fires following the Great Hanshin Earthquake in Kobe city by observing the buildings surrounding the fires and hearing the people who observed the fires. Table 3 indicates the fire stop factors for the major large fire sites whose area exceeds 33,000 square meters. [7]

Table 2. Number of Post-earthquake Fires by Area and Fire Loss [1), 6)]

Name of Ward and City	No. of Large Fires	No. of Middle Fires	No. of Small Fires	No. of Confined Fires	Total No. of Fires	Total Number of burned Buildings	Total area of fire sites m^2
Nishi	0	0	0	1	1	1	77
Tarumi	0	0	0	5	5	5	173
Suma	1	2	4	3	10	351	98,552
Nagata-Suma	2	-	-	-	2	1583	-
Nagata	14	3	2	3	22	2926	303,558
Hyogo	4	4	5	1	14	972	127,055
Kita	0	0	0	1	1	1	54
Chuo	0	3	3	16	22	88	14,542
Nada	3	4	6	5	18	561	65,318
Higashi-Nada	3	5	3	9	20	333	32,886
Kobe	27	21	23	44	115	6814	642,215
Ashiya	0	0	3	11	14	22	2,925
Nishinomiya	0	1	7	22	30	66	8,259
Takarazuka	0	0	3	11	14	-	-
Itami	0	0	0	7	7	7	-
Kawanishi	0	0	0	3	3	3	-
Amagasaki	0	2	0	5	7	10	2,090
Total	27	24	34	95	180	6922	655,489

Table 3. Fire Stop Factors at the Major Fire Sites [7)]

Major Fire sites	Main Street, Railroad	Open Space	Fire Resistive building	Suppression	Total m	Area [6)] m^2	Ignition Time
Mizukasa Nishi Park	42%	23%	27%	8%	2,345	121,783	7-9 a.m.
Sugawara Market	40	33	27	0	1,320	77,297	instant
Takahashi Hospital	65	24	10	2	1,258	68,850	instant
Eigeyama South	23	34	25	17	2,745	61,337	instant
Shin-Nagata Sta. S.	59	11	25	5	1,058	39,570	instant
Kobe Department S.	24	16	34	26	1,080	35,100	7 a.m.
Nishidai Market	23	25	28	24	1,195	34,407	instant
Total	38	25	25	12	11,001	438,344	-

Ignition time is of 17 January 1995.

Researchers at the Tokyo University headed by Professor Sugawara Shinichi and aluminum framed windows manufacturers conducted an investigation on the openings of houses surrounding the 27 fire sites. They pointed out that most of the windows that prevented the fire from spreading was aluminum framed windows with reinforced glass and concluded that the aluminum fire resistant doors at the openings of houses are essential for the prevention of the fire spreading because the fire spread is caused through the openings when the building itself is not damaged by the earthquake. [8]

FIRE SPREAD MECHANISMS AND VELOCITY

Tokyo Fire Department investigated the sites of the 11 large fires following the Great Hanshin Earthquake in Kobe city. Fire spread was investigated by hearing the people who observed the fires and fire fighters. Photographs taken from helicopters were also used to know the front lines of fire spread. Velocity of the fire spread was obtained by measuring the distance between front lines at different times. [9]

The Japanese Association for Fire Science and Engineering (JAFSE) conducted a survey to ask the people whose houses were burnt down or about to be burnt down. About 12,000 questionnaires were sent to the 47 urban fire sites and 32 apartment buildings where the fires were confined. About 3,600 people returned the questionnaires. In addition to this survey, JAFSE has been collecting the photographs which were taken during the fires to find out fire spread mechanisms. Over 1,000 photographs has been collected from newspapers, fire departments and the people who responded to the questionnaires. Questionnaires survey and collection of photographs has been supported mainly by FRI and BRI. The work is on the way but a complete result has not yet been obtained.

CIVIL ACTIVITIES

Researchers at the Kobe University headed by Professor Murosaki Yoshiteru investigated civil activities by hearing about 1,260 people at refuge sites. They asked the people's actions during and after the earthquake motion. Only 9 percent took action to prevent the ignition of fires because the shock was so intense to do so. In one to two hours after the shock, 36 percent of people went to nearby refuge sites because their houses were demolished. This early refuge made it impossible to take appropriate actions to prevent the ignition of fires and in fighting incipient fires. [10]. Kobe Fire Department conducted a similar survey by hearing about 860 people at refuge sites. [11]

According to the fire sites investigation by the Kobe University, civil fire fighting took place at 77 fire sites out of 94. 21 out of 24 confined fires were extinguished by the civil fire fighting. [3,4]

Civil fire fighting and other aspects of activities during the fires were also asked in detail in the questionnaires by the JAFSE. 33 percent out of people who used kerosene heaters at the time of earthquake turned off kerosene heaters, 34 percent turned off gas heaters and 51 percent turned off gas cooking stoves. As mentioned above, the work is on the way but a complete result has not yet been obtained.

HIGH-RISE FIRES

BRI investigated some fires in high-rise apartment buildings and combined the data with Kobe University's data to analyze the tendency of high-rise fires following the earthquake. [12, 13]

DAMAGES TO THE FIRE PROTECTION EQUIPMENT AND COMPARTMENTS

Researchers at Nagoya University headed by Tujimoto Makoto investigated the damages to the fire protection equipment and compartments. Fire Prevention Committee at Architecture Institute of Japan, Dr. Morita Masahiro at Science University of Tokyo, Construction companies and related companies, fire departments of Kobe City and Osaka City conducted similar investigations at some high-rise buildings. These investigations were conducted not for the occurred fires but for the future fires in high rise buildings because this time the earthquake took place very early in the morning and there were no major fires in high rise office buildings. [14-16]

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